sintering, resulting in a strong bond with a sharp interface between the two materials. FIGS. **4**A and B show cross-sectional images of the joint between decorated metal particles and a dense YSZ member. Sinter bonding of the joint members was achieved by co-firing in 4% H_2/96% Argon for 4 hours at 1300° C. Sinter bonds exist between: the individual metal particles; the decorating YSZ and the sintered YSZ particles; and, the sintered YSZ particles and the dense YSZ member. For comparison, physical mixtures of YSZ and metal particles were sintered onto similar dense YSZ substrates with and without a porous YSZ interlayer, resulting in a very weak bond or no bond. Thus, the decoration step is seen to be critical to the quality of the resulting metal-ceramic bond.

[0055] Improved bonding was achieved using a wide variety of YSZ particles as the decorating YSZ. The best bonds were achieved when using submicron-size YSZ particles (about 0.5 micrometer diameter), although decoration by particles and fibers with dimensions up to 10 micrometer also promoted bonding. The range of YSZ loading during the decoration step was varied between 1:99-4:96 weight ratio of YSZ to metal. Good bonding was observed over this entire range, with the strongest bond occurring for the 4:96 ratio. Higher YSZ loadings were not studied because the metal surface seemed to be saturated with YSZ at the 4:96 ratio, with some excess YSZ filling the pores between the decorated metal particles. This excess YSZ would block gas transport in a working fuel cell and is therefore undesirable for that application. Other applications of the invention might not require an open pore structure, in which case higher loadings of the decorating material would be appropriate.

CONCLUSION

[0056] Thus, the invention encompasses a decoration/sintering joining method suitable for dissimilar materials having different ductility resulting in a strong bond with a sharp interface between the two materials. Composites and devices with a decorated/sintered interface are also provided.

[0057] Although the foregoing invention has been described in some detail for purposes of clarity of understanding, it will be apparent that certain changes and modifications may be practiced within the scope of the appended claims. It should be noted that there are many alternative ways of implementing both the process and compositions of the present invention. Accordingly, the present embodiments are to be considered as illustrative and not restrictive, and the invention is not to be limited to the details given herein.

[0058] All references cited herein are incorporated by reference for all purposes.

1. A method of joining dissimilar materials having different ductility, the method comprising:

decorating the more ductile of the materials with particles of a less ductile material to form a composite;

joining the composite and a joining member comprising a less ductile material by sintering.

2. The method of claim **1**, wherein the less ductile material decorated on the more ductile material is the same as the less ductile material of the joining member.

3. The method of claim **1**, wherein the less ductile material decorated on the more ductile material is different than the less ductile material of the joining member.

4. The method of claim **1**, wherein the more ductile material is a metal, the less ductile material decorated on the more ductile material is a ceramic and the joining member is a ceramic or cermet.

5. The method of claim **1**, further comprising joining an additional member comprising the less ductile material or another material that can sinter-bond to the joining member by sintering, such that the joining member is an interlayer between the composite and the additional member.

6. The method of claim **5**, wherein the more ductile material is a metal, the less ductile material decorated on the more ductile material is a ceramic, the joining member is a ceramic or cermet, and the additional member is a ceramic or cermet.

7. The method of claim **6**, wherein the additional member is a dense piece and the joining member is a porous piece or particulate.

8. The method of claim **4**, wherein the more ductile material is stainless steel and the less ductile material decorated on the more ductile material and the joining member are both the ceramic YSZ.

9. The method of claim **4**, wherein the more ductile material is stainless steel, the less ductile material decorated on the more ductile material is YSZ, and the joining member is a mixed ionic-electronic conductor.

10. The method of claim **6**, wherein the more ductile material is stainless steel and the less ductile material decorated on the more ductile material, the joining member and the additional member are both the ceramic YSZ.

11. The method of claim **10**, wherein the joining member is porous and the additional member is dense.

12. The method of claim **1**, wherein the pre-sintered size of the particles of less ductile material used to decorate is between about 10 and 0.05 micrometers.

13. The method of claim **12**, wherein the particle size is about 0.5 micrometer.

14. The method of claim **1**, wherein the decoration partially covers the more ductile material surface.

15. The method of claim **14**, wherein between about 10-80% of the surface area of the more ductile material is decorated with the less ductile material.

16. The method of claim **14**, wherein between about 20-30% of the surface area of the more ductile material is decorated with the less ductile material.

17. The method of claim **14**, wherein between about 30-60% of the surface area of the more ductile material is decorated with the less ductile material.

18. A composite of dissimilar materials having different ductility, the composite comprising:

a more ductile material;

a less ductile material;

an interface between the more and less ductile materials comprising particles of a less ductile material decorated on the surface of the more ductile material and sintered to the less ductile material.

19. The composite of claim **18**, wherein the less ductile material decorated on the more ductile material is the same as the less ductile material of the joining member.

20. The composite of claim **18**, wherein the less ductile material decorated on the more ductile material is different than the less ductile material of the joining member.

21. The composite of claim **18**, wherein the more ductile material is a metal, the less ductile material decorated on the more ductile material is a ceramic and the joining member is a ceramic or cermet.